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I also certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an amendment, effected by this office, following a request by the applicant and agreed to by the Comptroller-General.

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Dated 11 May 2005

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## Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)



The Patent Office

 Cardiff Road  
 Newport  
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## 1. Your reference

P 10557.GB JMP.KT

## 2. Patent application number

(The Patent Office will fill in this part)

0031542.4

## 3. Full name, address and postcode of the or of each applicant (underline all surnames)

 Simage Oy  
 Olarinluoma 15  
 00220 Espoo  
 Finland

Patents ADP number (if you know it)

7347016002

If the applicant is a corporate body, give the country/state of its incorporation

Finland

## 4. Title of the invention

A Radiation Imaging System, Device and Method for Panoramic Imaging

## 5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Julian Potter

 D Young & Co  
 21 New Fetter Lane  
 London EC4A 1DA

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 SUITE 308, THE FOUNDRY  
 156 BLACKFRIARS ROAD  
 LONDON  
 SE1 8EN

Patents ADP number (if you know it)

59006

08144297002 FS1/77 03.05.0

## 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)Date of filing  
(day / month / year)

## 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:  
 a) any applicant named in part 3 is not an inventor, or  
 b) there is an inventor who is not named as an applicant, or  
 c) any named applicant is a corporate body.  
 See note (d))

yes

# Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

Description 5 /

Claim(s) 1-

Abstract

Drawing(s) 2+2 /

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10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

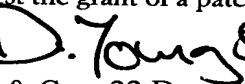
Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents  
(please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature  Date  
D Young & Co - 22 December 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

Dr Julian Potter - 020 7353 4343

## Warning

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## Notes

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- d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- e) Once you have filled in the form you must remember to sign and date it.
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## A RADIATION IMAGING SYSTEM, DEVICE AND METHOD FOR PANORAMIC IMAGING

The present invention relates to a high energy imaging system, device and method. In particular, but not exclusively, the invention relates to multi-slice tomographic panoramic imaging systems.

In traditional panoramic imaging, the X-ray source and the film cassette are located on opposite sides of a patient's head. During an exposure, the X-ray source and the film cassette are rotated around the patient's head. The centre of rotation does not remain stationary but is also moved along a predefined path. The X-ray beam is collimated and is typically very narrow and therefore only a narrow part of the film is exposed at any time. The film cassette is also moved during the exposure. The speed of the rotation, the speed of the cassette movement and the X-ray intensity is varied during the exposure to compensate for the different X-ray absorption in different parts of the skull. The speed of the film cassette is chosen in a way that a wanted layer is projected sharp in the final image. Panoramic imaging with film cassette is illustrated in Figure 1. In the image, two positions for the X-ray source, X-ray beam and the film cassette are shown. This illustrates the rotating operation of a panoramic imaging system. The direction of rotation is shown with arrows. Also, the direction of film cassette movement and the movement of the centre of rotation are indicated with arrows.

An aspect of the invention provides an imaging system for imaging high energy radiation comprising:

a radiation source member for providing radiation with energy more than 1 keV; and

a semiconductor imaging device;

said radiation source member and said semiconductor imaging device disposed about an object location region for said system;

wherein at least one of either said radiation source member or said semiconductor imaging device and said object location region are movable with respect to each other for illuminating a part of an object disposed in said object location region from two or more directions; and

wherein said semiconductor radiation imaging device comprises a plurality of imaging cells for producing image cell output values and further comprises readout circuitry for individually addressing at least some of said imaging cells, said read-out circuitry operable to read out an image cell value from each of said individually addressable imaging cells a plurality of times during image acquisition.

Another aspect of the invention provides an imaging system for imaging high energy radiation comprising:

a radiation source member for providing radiation with energy more than 1 keV; and

a semiconductor imaging device;

said radiation source member and said semiconductor imaging device disposed about an object location region for said system;

wherein at least one of either said radiation source member or said semiconductor imaging device and said object location region are movable with respect to each other for illuminating a part of an object disposed in said object location region from two or more directions; and

wherein said semiconductor radiation imaging device comprises a plurality of imaging cells for producing image cell output values and further comprises readout circuitry for individually addressing at least some of said imaging cells, said read-out circuitry operable to read out an image cell value from each of said individually addressable imaging cells at least once in a time interval during which any point within said part to be imaged for an object is projected onto said imaging device over a distance that is not substantially larger than the size of an imaging cell along the direction of movement.

In a preferred embodiment, each of said imaging cells are read out multiple times in said time interval.

Preferably, the radiation source member comprises a mount for a radiation source for producing radiation having an energy greater than 1 keV.

Yet further preferably, said object location region is fixed.

An example of a digital imaging device for panoramic imaging has been developed. The imaging device consists of a semiconductor detector flip-chip bonded to a CMOS read-out circuit. CdTe or CdZnTe is used as detector material offering superior quantum efficiency. Construction of a sensor tile is shown in figure 2. Other detector materials can be used as well. The sensor consists of 8 detector tiles, each of size  $1.08 \times 1.80 \text{ mm}^2$  and with a  $100 \mu\text{m}$  pixel pitch. A different number of tiles can be used to create a smaller or larger imaging area. Multiples of tiles can be butted together in order to create a continuous imaging area. The dimensions and pixel pitch of the sensor tiles are not limited to the numbers mentioned above.

Because the X-ray beam is typically very narrow in the panoramic systems, the CMOS read-out circuit has been designed with that in mind. The pixel addressing is preferably done column by column. The chip can also be operated in 4 different operating modes: full CMOS, 8 mm, 6 mm, and 4 mm. The operating mode can be selected according to the X-ray beam width of the system. For example, if the width of the X-ray beam is 4 mm or less, the CMOS read-out device can be set to operate in the 4 mm mode. This means that only a 4 mm wide strip from the centre of the detector is read. By doing this, less pixels have to be read, reducing the data to be processed and also reducing the amount of data to be transferred. In other words, the operating modes can be used to select the active area of the detector. The number of operating modes is by no means limited to 4. The operation of different modes for selecting the active area is illustrated in Figure 3.

The CMOS read-out circuitry provides means for connecting several sensor tiles together. With control signals, the entire area can be scanned as one sensor or the sensor tiles can be grouped into smaller groups. For example, four 2-tile groups can be

selected. This enables use of several parallel channels for the processing of output data. The data rates in panoramic systems can be very high and therefore it may be necessary to use more than one read-out channel.

In addition to being able to select the active area according to the used X-ray beam width, the CMOS frame read-out offers an additional advantage compared to traditional film-based systems and CCD-based systems running in time-delayed integration (TDI) mode. In this invention, the output is frame output at a very high frame rate. Any pixel in the final digital panoramic image consists of several pixel values from different frames. The final image is constructed of several frames partly overlapping each other. The reconstruction of the image can be done in a computer or in hardware. In a panoramic image, a wanted layer is displayed or manifest as a sharp region in the image and everything else is more or less motion-blurred, depending on how far from the sharp layer the object is. Typically, this layer is selected to follow the centreline of teeth. However, different people have different sized skulls and the sharp layer is not always where the doctor would want it to be.

With the frames stored separately in hardware or in computer memory, there are more possibilities to reconstruct the final image or several images can be created with sharp layers at different depths. From the stored frames, several layers can be produced and viewed on the computer screen. This can be taken even further by constructing a 3D image using the stored frames.

In the digital system, the film cassette is replaced by a digital sensor. Unlike in the film-based systems, the sensor is very narrow, much narrower than the film cassette. The sensor is only slightly wider than the X-ray beam. In film systems, the desired projection is achieved by moving the film cassette as the system rotates keeping the projection of desired layer stationary on the film level. In the digital system, the sensor remains stationary reading out frames at a high speed. High frame read-out is necessary to prevent motion blurring in the direction of rotation. The frames are stored for later processing by hardware or computer software. Alternatively, the frames can be processed in real time. As new frames are acquired

they are added to the previous image by shifting them in the direction of the rotation so that the same objects in the two frames overlap each other. The amount of shifting can be calculated when the speed of rotation, the frame rate, the centre of rotation and the position of the desired object layer are known.

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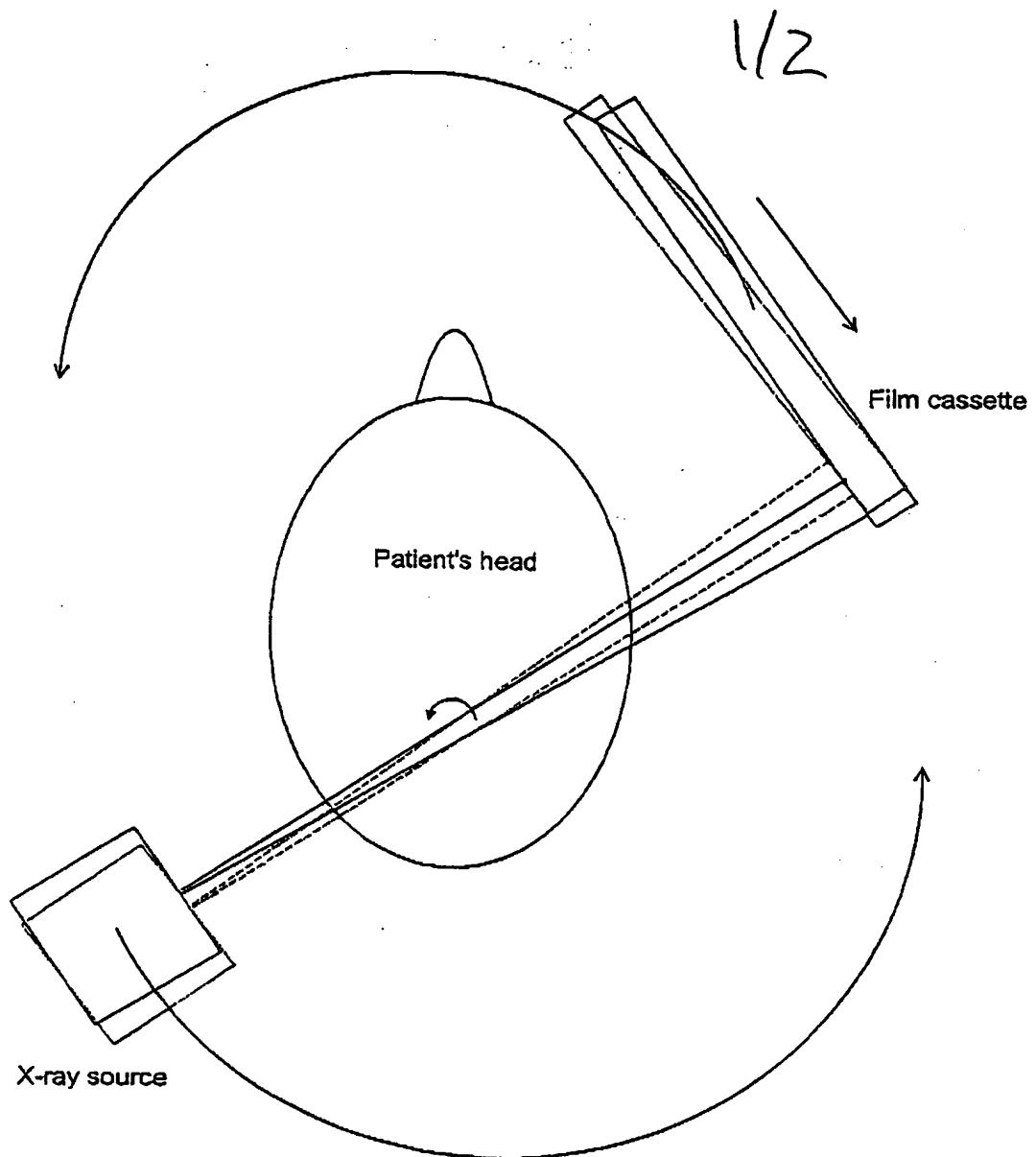


Fig. 1. Panoramic X-ray imaging

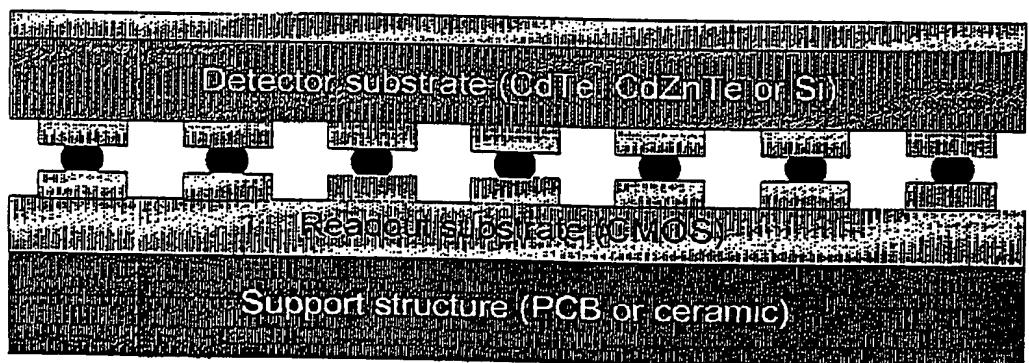


Fig. 2. Sensor tile

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2/2

inactive area

active area

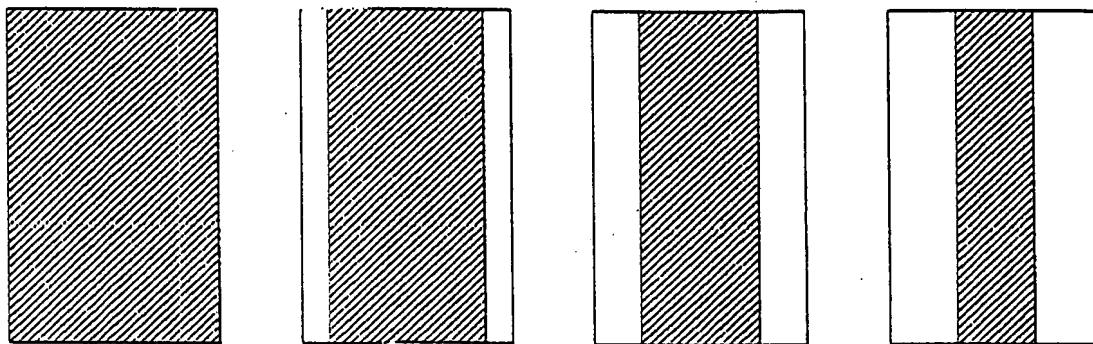


Fig. 3. Choosing the active area of one sensor tile

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